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EQUIPMENT FOR APPLYING DUST FUNGICIDES TO SEED GRAIN

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CONTENTS

	Page		Page
Introduction.....	1	Experimental feeders.....	9
Commercial treaters.....	2	Fungicide feeders.....	9
Feeders.....	2	Grain and fungicide feeder.....	17
Mixers.....	6	General precautions in handling fungicides.....	19
Timing for hand feed.....	7		

INTRODUCTION

In applying dust fungicides to seed grain to control smuts and other diseases, two things are essential: (1) That the correct quantity of dust be applied, and (2) that it be thoroughly mixed with the grain. It is common knowledge that if the dust fungicides now in general use are fed into the grain stream at the proper rate and the two then thoroughly mixed, effective disease control is obtained.¹

The application of too much dust to the seed is undesirable, as the seed will retain only a given quantity of dust and the excess is wasted. In addition, excess dust may cause a dust fog which is disagreeable to the operators and inimical to their health. The excess dust also may reduce the rate of seeding or clog the drill. Certain dusts, if applied at more than the prescribed rate, may injure the seed and cause poor germination or weak, deformed seedlings. On the other hand, an insufficient amount of dust may result in poor disease control. The objections which apply to inadequate application apply also to inefficient methods of mixing. If the proper amount of dust is added to but not thoroughly mixed with the seed, some of the seeds receive too much and may be injured while others are not sufficiently coated with dust to be protected from infection.

With the small-capacity batch mixers in general use on farms, or with the larger ones used in some commercial establishments, the problem of rate and thoroughness of application is easily controlled, as a definite quantity of dust is added to an equally definite weight of seed and the two then are mixed until all the seeds are coated. This

¹ HANNA, W. F., and PAPP, W. EXPERIMENTS ON THE CONTROL OF CEREAL SMUTS BY SEED TREATMENT. Sci. Agr. 15, 745-753. 1935. JOHNSON, A. G., HASKELL, R. J., and LEUKEL, R. W. TREAT SEED GRAIN. U. S. Dept. Agr. Misc. Pub. 219, 4 pp. 1934. KOEHLER, B. SEED TREATMENTS FOR THE CONTROL OF CERTAIN DISEASES OF WHEAT, OATS, AND BARLEY. Ill. Agr. Expt. Sta. Bull. 420, pp. 499-575, illus. 1935.

is true also of certain continuous mixers into which definite measured quantities of grain and dust are fed by hand intermittently. However, when the latter type of machine is used in connection with seed cleaning or other equipment so that there is a continuous flow of grain into the seed treater, it becomes desirable to have a mechanical device for adding the proper amount of dust fungicide to the grain.

During the past few years there has been a growing tendency on the part of seedsmen, grain dealers, elevator and mill operators, and other central agencies to take over the work of treating seed grain. The purchase of millions of bushels of seed grain in 1934-35 by the United States Department of Agriculture and its redistribution and sale in the drought areas greatly promoted the centralization of seed-treating operations in those areas, as the distribution was carried out largely through the above-mentioned agencies. A sudden demand was created for large capacity seed-treating equipment, capable of handling the output of seed-cleaning machinery such as is found in mills, elevators, and seed houses.

The seed-treating devices found on the market at that time were designed largely for applying copper-carbonate to wheat at 2 or 3 ounces per bushel. They were on the whole, unsuitable for the more exacting work of accurately applying certain organic mercury dusts at the proper rate, usually one-half ounce per bushel, when treating wheat, oats, and barley at from 200 to 500 bushels per hour. Several types of seed-treating machines of large capacity equipped with dust-feeding devices were immediately designed and offered for sale by certain commercial concerns. In tests made by the writers some of these devices, designed for feeding fungicidal dusts into the grain stream at a definite rate per bushel, were found inaccurate and unreliable. In applying certain fungicides to seed the use of accurate dust-feeding devices is highly essential. Since little general information was available regarding the specifications and requirements for equipment of this kind, investigative work in testing and developing grain-treating equipment for large-scale operations was begun in 1934 by the Bureau of Plant Industry and Agricultural Engineering of the United States Department of Agriculture.

COMMERCIAL TREATERS

FEEDERS

As previously stated, most of the commercial seed-treating machines on the market prior to 1934 were designed primarily for applying dusts such as copper-carbonate to wheat at 2 to 3 ounces per bushel. Some were designed to be used in connection with fanning mills or other types of seed cleaners. The fungicide usually was added to the grain by means of some mechanical device operated either by the movement of the grain or by direct connection with the cleaning or treating mechanism. Since the dusts were applied at a relatively high rate, a glance at the treated grain was sufficient to determine whether enough dust was being added to thoroughly coat the seed, while an excessive charge manifested itself as free dust. About 1933, however, ethyl mercury phosphate, an organic mercury compound, came into use as a fungicide for cereals, and the rate of application was restricted to only one-half ounce per bushel. Attempts to apply this dust mechanically at the proper rate with the equipment

then available were generally unsuccessful. Since that time, however, considerable work has been done by commercial, State, and Federal agencies in developing suitable equipment.

Fungicide feeders vary widely as to design and construction. To show all such variations is beyond the scope of this publication, and the illustrating of certain types should not be construed as implying any endorsement by the Department.

Figure 1 shows diagrammatically a feeder in which a chain is used to drag the dust from a trough beneath an opening in the bottom of a hopper. The drag is ratchet-driven and provided with adjustments for varying the speed which in turn controls the rate of discharge of the dust to a mixer. Agitators in the hopper are designed to prevent bridging or arching of the dust over the opening through which it moves by gravity to the trough. Power for operating the feeder may be supplied by a motor or it may be driven from some moving part of a cleaner or mechanically operated mixer with which the feeder is used.

A feeder with revolving wheel (*c*) for feeding the dust to the mixer is illustrated in figure 2, *A* and *B*. This wheel, on a horizontal axis, is situated below holes in the side of the hopper (*g*) through which the dust is allowed to fall. A cuplike container (*d*) formed by flanges and a wiper over the rim of the feeder wheel is kept full of dust. The rate at which the dust is removed from the cup on the rim of the wheel depends on the speed of the wheel.

The feeder wheel is ratchet-driven (*e*) and the number of revolutions it makes per minute is controlled by a swinging valve (*b*) in the grain spout (*a*) to which is attached a weight arm and an adjustable weight. This weight can be so adjusted that the damper is held in a closed position and no dust is fed when no grain moves through the spout. As the damper is opened by the movement of grain a lever attached to the weight-arm shaft moves a guard or shield (*f*) on the ratchet drive, exposing one or more teeth for the pawl to engage. The wider the damper opens the greater the number of ratchet-teeth exposed and the faster the feed wheel turns in relation to the driving member.

This feeder was designed for use with an itinerant grain-cleaning-and-treating outfit and is driven from a shaft on the cleaner. Agitators (*h*) are provided in the hopper for stirring the dust and for keeping a supply in the feeder wheel cup.

In figure 3 is diagrammatically illustrated a hand-operated feeder in which the dust is fed through holes in a slide operated in a trough at the bottom of a hopper. Cords are attached to the slide, one at each end, and extend through pulleys. Stops are provided which permit the operator to move the slide only a given distance. As it approaches the stop the slide is in such position that one end extends beyond the

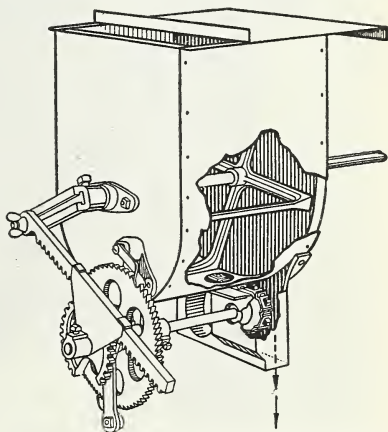


FIGURE 1.—Feeder with ratchet drive and chain drag for feeding fungicide dust to mixer.

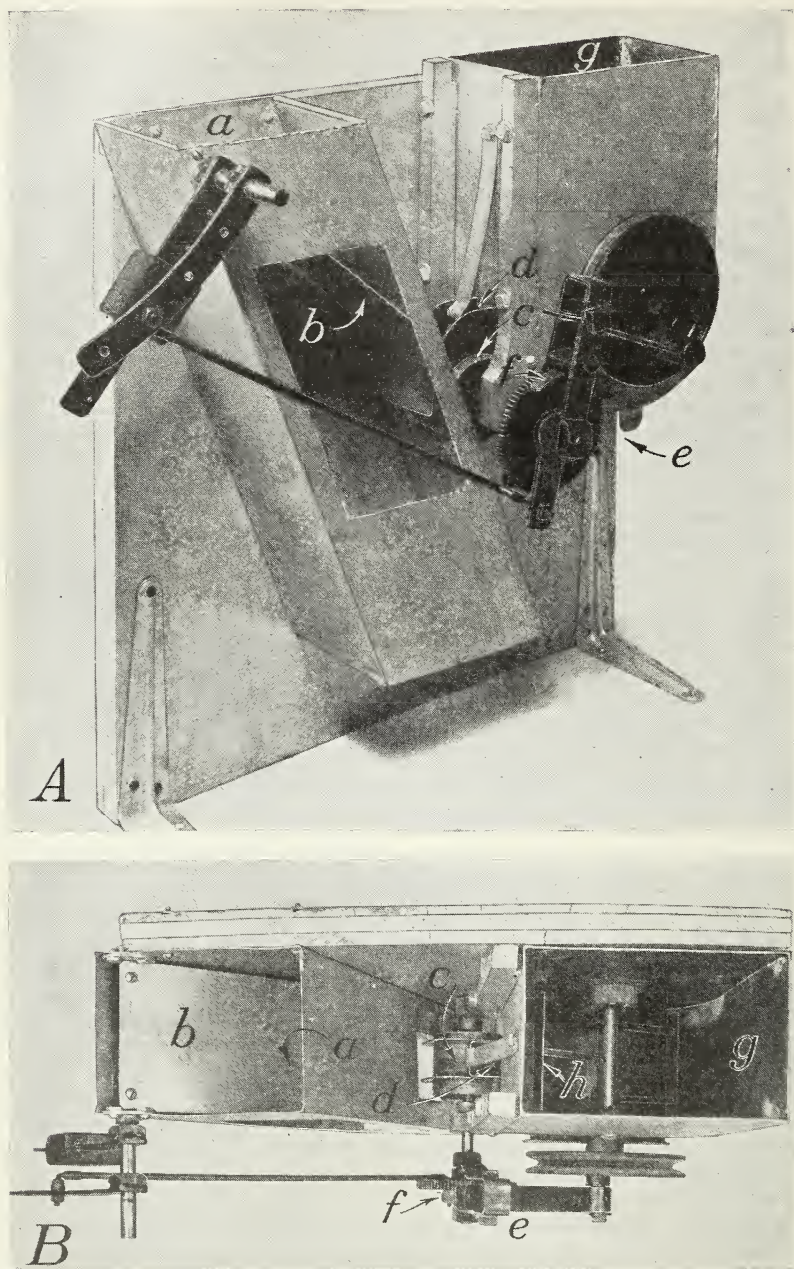


FIGURE 2.—Revolving wheel ratchet drive fungicide feeder: *A*, Side view; *B*, top view. *a*, Grain spout; *b*, grain valve; *c*, feeder wheel; *d*, feeder cup; *e*, ratchet drive; *f*, ratchet guard; *g*, dust hopper; *h*, agitator.

end of the trough and the charge of dust accumulated in the hole is deposited. When the slide is moved in the opposite direction a pre-determined quantity of dust is likewise ejected from that end of the trough through a hole in the slide.

For the successful operation of this feeder the operator must know the rate at which grain is being fed to the mixer. With this information it is necessary for him to move the slide a sufficient number of times per minute for feeding the required quantity of dust. A watch with second hand or a stop watch may be used in timing the trips.

A motor-driven feeder in which the dust is metered through small holes in the bottom of a hopper is shown in figure 4. A rocker arm

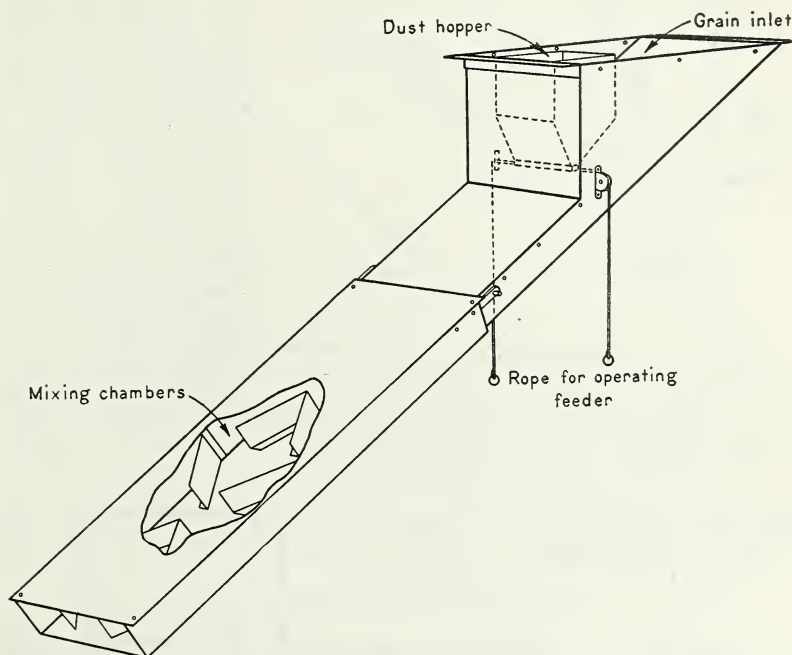


FIGURE 3.—Hand-operated feeder with slide ejector for dust.

with wipers is provided in the hopper for agitating the dust. In operation these wipers just clear the bottom of the hopper in moving back and forth. Several rows of holes in line with the movement of the wiper are provided and each time the wiper completes its stroke a charge of dust is deposited from each hole. After the wiper moves past an individual hole the dust immediately bridges over the hole and no more is fed until the wiper again breaks the arch.

A gate or sheet-metal slide is provided for each row of holes and mounted just under the hopper. By moving this slide any desired number of holes per row may be opened to allow the dust to feed through.

A feeder in which an auger is employed for depositing the dust is shown diagrammatically in figure 5. The auger, which is usually about 1 inch in diameter, is mounted in the bottom of the dust box and rotated by mechanical means. One end of the trough is open and the

other closed. The closed end forms a bearing for the auger shaft but the opposite end is allowed to turn in a collar or sleeve, only slightly larger than the auger, through which the dust is ejected.

The outer end of the sleeve is equipped with an adjustable damper or valve set at right angles to the axis of the auger. When only partly open sufficient pressure is exerted by the auger to force out some of the dust but not all. In this manner and by changes in speed

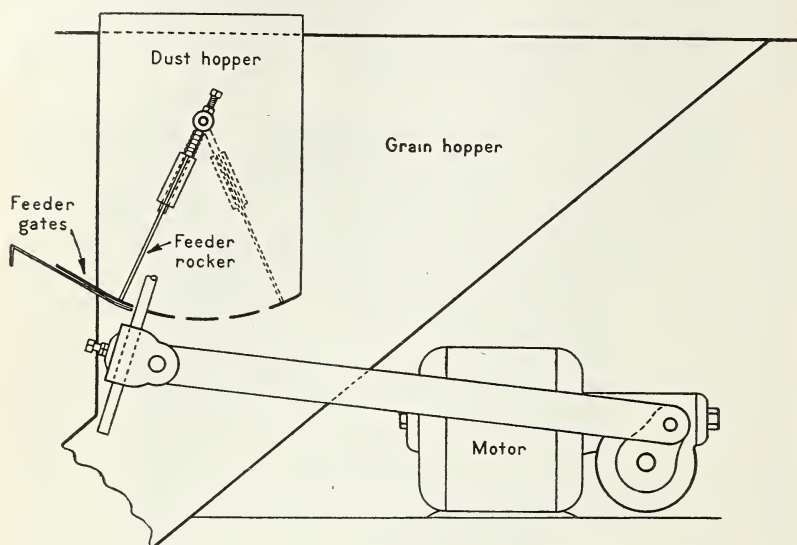


FIGURE 4.—Motor-driven feeder with perforated hopper bottom and agitator.

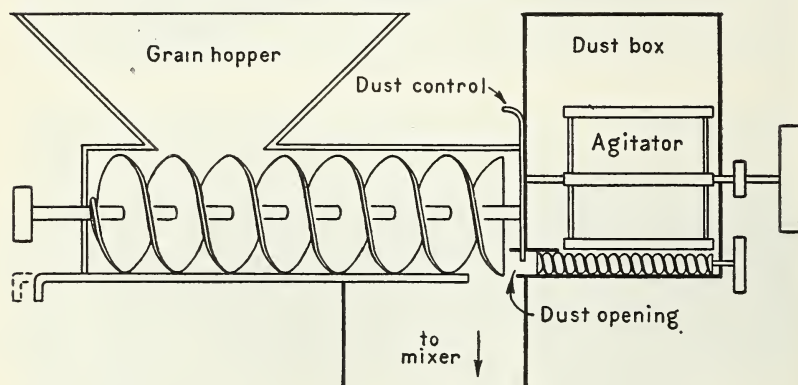


FIGURE 5.—Auger-type dust feeder.

adjustments are made for rate of feeding the dust. The grain to be treated is also fed to the mixer by an auger with provision for adjustment.

MIXERS

After the fungicide is fed to the grain, mixing is usually accomplished by tumbling the grain and fungicide in a cylinder, moving them with

a screw conveyor equipped with paddles for agitation, or by allowing the grain and fungicide to move by gravity through a chute equipped with baffles.² Figure 6 illustrates a mixing chute designed for operation at an angle of about 45° and figure 7 a cylinder in which cones are used.

In preliminary tests of gravity-type mixers hulled sweetclover seed was used to determine the uniformity of mixing. The sweetclover seed were fed by hand or by mechanical means to the grain as it moved by gravity to the mixer and the mixture allowed to fall into a box. A grain probe was used for sampling and the contents of each cell or pocket in the probe kept separate from the others while dumping the grain on a tarpaulin. About nine probe samples were taken for test. With this method samples representing horizontal strata in the box were obtained. The sweetclover seed was screened from the grain and weighed as well as the grain from which it was removed. Results of such tests as well as others in which the dust was mixed with the grain indicated satisfactory performance for gravity mixers of the types illustrated in figures 6 and 7 for organic mercury dust.

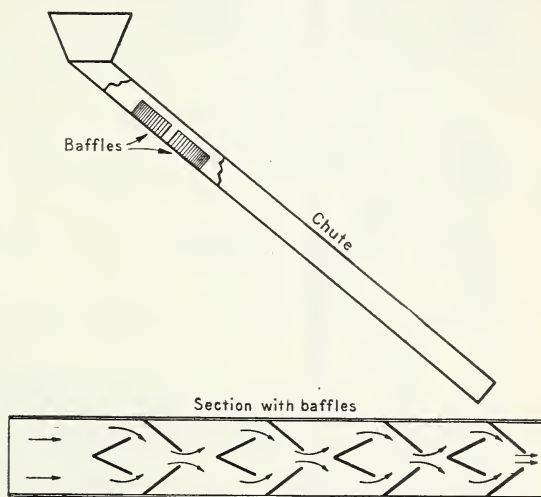


FIGURE 6.—Mixing chute for operation at an angle of about 45°.

TIMING FOR HAND FEED

One advantage claimed for the gravity-type mixers is that no power is required except for elevating the grain. However, unless the grain to be treated is sacked, difficulties are involved in timing for hand feeding of the fungicide. When a hopper with a given size opening was employed for feeding, the head or depth of grain over the opening was found to influence the rate of feed. Even with a constant head, variations in rate of flow occurred, due in part to differences in physical characteristics of the several kinds of cereal grain.

Table 1 gives the rate of flow in calibration tests with one lot each of wheat, oats, and barley through funnels of a particular size and shape but with different size openings. These funnels were used in testing several treaters in which the time consumed and the quantity of grain used were known and the rate of flow checked fairly well with results given in table 1.

² MEIER, F. C., BOERNER, E. G., BODNAR, G. P., LEIGHTY, C. E., and COKE, J. C. THE COMBINATION CLEANING AND TREATING OF SEED WHEAT. U. S. Dept. Agr. Leaflet 33, 8 pp., illus. 1929.

HOFFMAN, A. H., and BELTON, H. L. MACHINES FOR COATING SEED WHEAT WITH COPPER CARBONATE DUST. Calif. Agr. Expt. Sta. Bull. 391, 16 pp., illus. 1925.

As the hand feeding of dust to grain from a calibrated hopper was considered somewhat impracticable, efforts were made to develop a timing device which would indicate the rate of flow of grain and thereby eliminate the use of a stop watch. This work was done in cooperation with a commercial firm interested in the development and use of seed treaters.

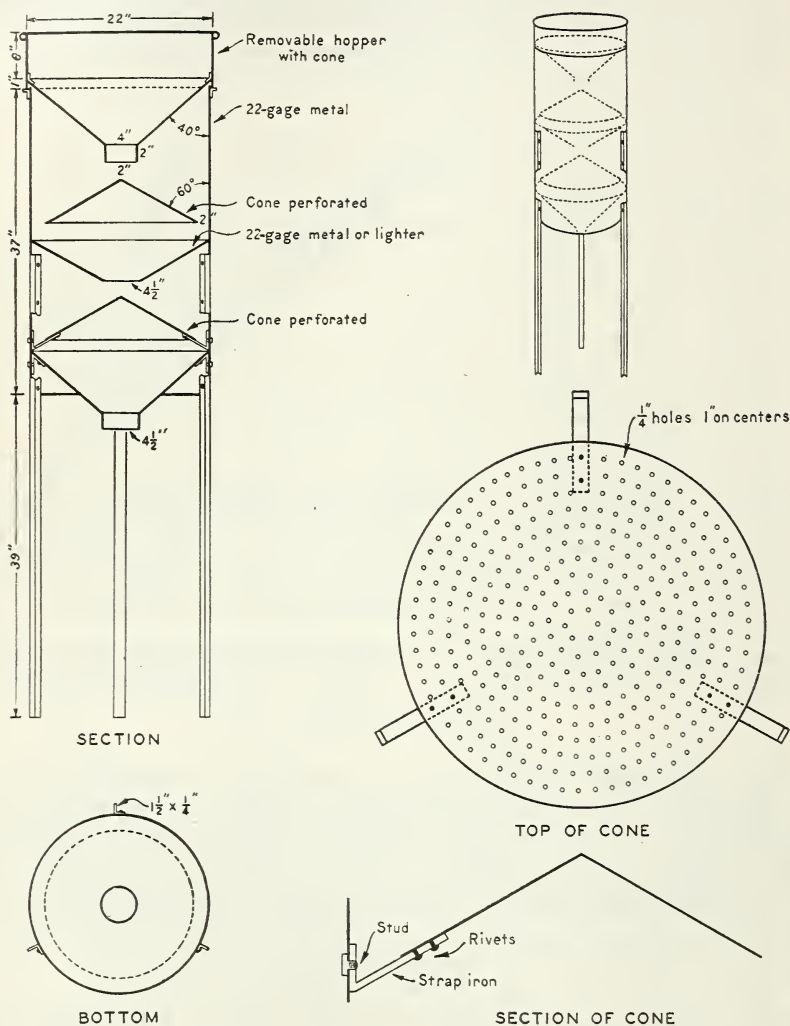


FIGURE 7.—Cylindrical mixer with perforated cones.

The mixer used was of the type illustrated in figure 2. A steel plate with numerous small holes for the grain to feed through was placed in a hopper in a horizontal position just above the funnel. These holes were all of the same size thus permitting the grain to pour through each at about the same rate but with a total capacity somewhat less than that of the funnel opening. As the grain was

TABLE 1.—*Grain flow through funnels of different sizes*¹

Grain	Flow per hour for diameter of opening indicated			
	2½ inches	3 inches	3½ inches	4 inches
	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>
Wheat.....	140	264	405	547
	140	266	406	567
	140	260	402	558
		260		
		264		
		268		
Average.....	140	264	404	557
Oats.....	(2)	250	378	496
	(2)	243	445	574
	(2)	232	347	594
	(2)	257	346	468
Average.....		245	379	533
Barley.....	(2)	244	355	483
	(2)	234	351	451
	(2)	207	329	445
	(2)	216	323	449
	(2)	216	341	
Average.....		223	340	457

¹ Hopper kept full throughout test.² Clogged.

discharged from the hopper into the funnel at numerous points all at about the same rate the entire mass of grain in the hopper tended to move downward at a uniform rate. With this arrangement an object placed in the grain would move downward at the same speed as the surrounding kernels. Metal strips in the form of a cross were used for this purpose to which was attached a cord extending through a pulley and equipped with adjustable stops. The stops were adjusted so that a bushel of grain was fed each time the weight moved a given distance with the grain. An electric buzzer was connected to the device in such a manner that the buzzer would operate each time the weight reached its lowest position indicating that it was time to add a charge of fungicide. It was, of course, necessary for the operator to raise the weight by pulling on the cord each time the weight reached its lowest position. Results of tests made with the timing device indicated considerable promise, but the danger of dust explosions caused by a spark from the electrical apparatus and the necessity for continuous hand operation in moving the weight were objectionable.

EXPERIMENTAL FEEDERS

FUNGICIDE FEEDERS

Dust fungicides usually are difficult to feed accurately by mechanical means because they will not flow readily down an incline and will pack and bridge easily due to their high coefficient of friction. These tendencies to remain immobile and to form a vertical hollow column or well, or to bridge above an opening in the bottom of a hopper, were the chief obstacles to be overcome in the development of equipment for the accurate feeding of fungicidal dusts by mechanical means.

In experimental work on seed treaters special attention was given to mechanically operated feeders and a device in which the feeding of the dust might be synchronized with that of the grain fed to the mixer.

Results of tests with several different types of mechanically operated feeders indicated that the height of the dust in the hopper over the dispensing mechanism influenced the rate of feed. On some feeders the quantity of dust fed per unit of time varied with the depth of dust in the hopper. In most cases the feed was heavier with the hopper full than when partly empty. This indicated the desirability of a hopper and dispensing apparatus not affected by the quantity of dust in the hopper. In an attempt to overcome this difficulty, two feeders with offset hoppers were developed and found to possess merit. Two additional feeders in which the dispensing mechanism tended to minimize the effect of head on the rate of feed were also constructed. Feeders of the type referred to are illustrated diagrammatically in figures 8, 9, 10, and 11 and a grain and fungicide feeder in figure 12.

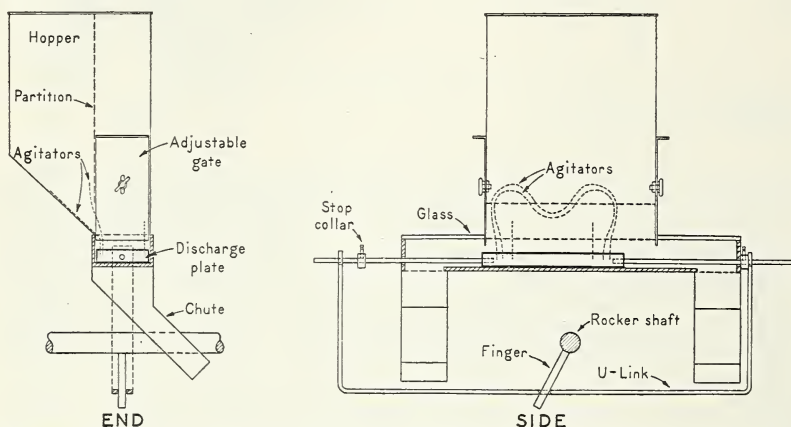


FIGURE 8.—Offset-hopper fungicide dust feeder with reciprocating discharge plate above hopper bottom.

The feeders illustrated in figures 8, 9, and 12 are covered by patents dedicated to the public.

The feeder illustrated in figure 8 consists of a rectangular sheet-metal hopper having a bottom made of a piece of light channel iron supporting a reciprocating slide. The ends of the channel iron extend beyond the sides of the hopper forming narrow side openings through which the slide pushes the dust. A discharge plate is also provided on each side above the openings. The quantity of dust fed may be adjusted by varying the height of the openings or the length of the stroke of the reciprocating discharge plate. Wire-loop agitators attached to the slide extending well up into the hopper prevent bridging or clogging. The partition across the hopper parallel with the reciprocating plate forms two compartments, one directly above the plate, and the other to one side. With this arrangement the depth of dust directly above the discharge plate is maintained at a fairly constant level regardless of the quantity of dust in the side hopper. Table 2 shows results of tests with a feeder of this type

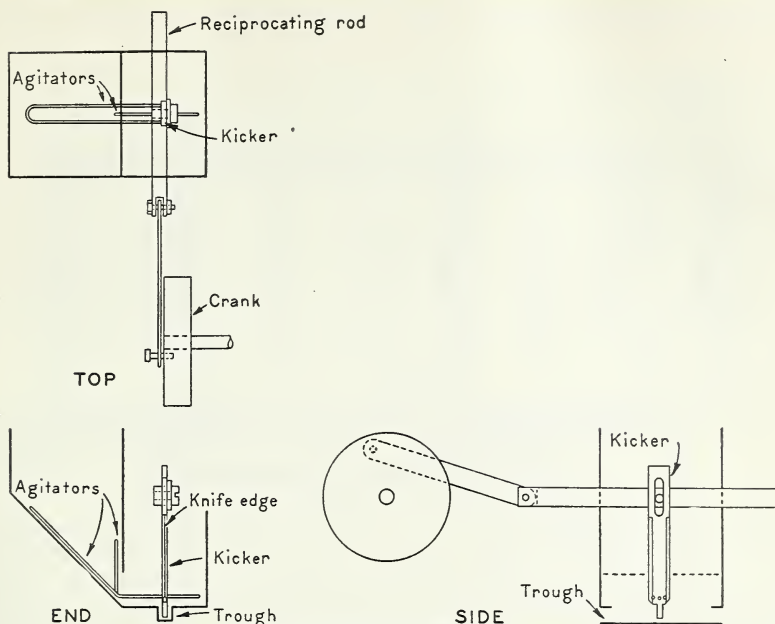


FIGURE 9.—Offset-hopper fungicide dust feeder with reciprocating kicker.

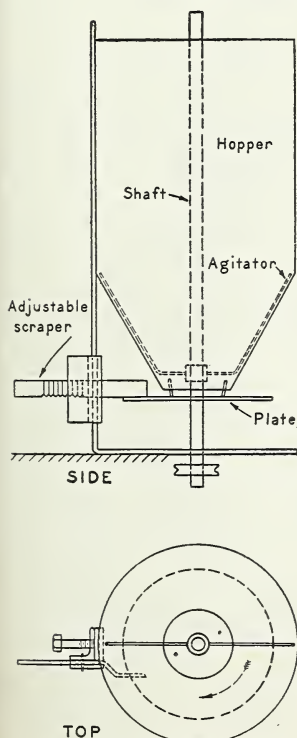


FIGURE 10.—Cylindrical-hopper disk type fungicide dust feeder.

operated by hand. This feeder was later attached to a device operated by the weight of the grain being treated, and satisfactory performance was obtained.

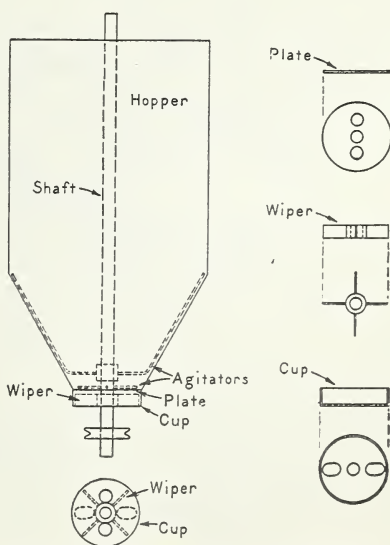


FIGURE 11.—Cylindrical-hopper perforated-plate two-stage wiper type fungicide dust feeder.

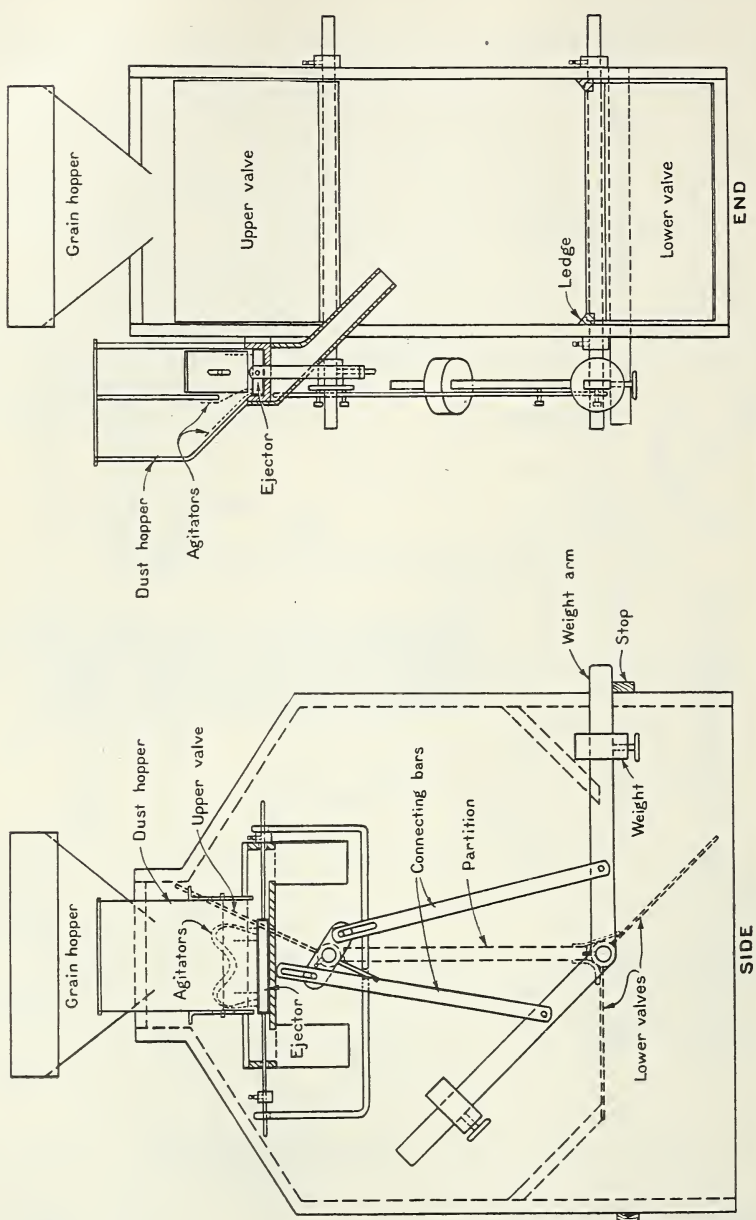


FIGURE 12.—Automatic grain and fungicide feeder.

TABLE 2.—Discharge of organic mercury dust per bushel from hand-operated offset hopper illustrated in figures 8 and 12 ¹

Left stroke	Right stroke	Left stroke	Right stroke	Left stroke	Right stroke	Left stroke	Right stroke
<i>Ounces</i>	<i>Ounces</i>	<i>Ounces</i>	<i>Ounces</i>	<i>Ounces</i>	<i>Ounces</i>	<i>Ounces</i>	<i>Ounces</i>
2 ³ 0.41	0.48	0.53	0.60	0.51	0.53	0.60	0.60
.44	.51	.44	.53	.49	.62	.44	.64
.48	.53	.49	.53	.53	.55	.56	.64
.52	.51	.53	.67	.53	.51	.48	.60
.76	.67	.56	.60	.64	.60	.53	.58
.51	.56	.56	.60	.60	.60	.58	.55
.51	.55	.60	.64	.56	.56	.49	.49
.46	.48	.67	.64	.56	.56	4.54	4.57
.53	.44	.53	.58	.55	.53		
.42	.49	.56	.55	.48	.53	.35	.35
.49	.55	.53	.60	.53	.67	.14	.16
.67	.56	.55	.56	.53	.65	.09	.12
.48	.64	.58	.60	.55	.60		

¹ Dust caught and weighed each stroke, corresponding to $\frac{1}{2}$ bushel per trip of grain feeder.² Not used in computing average.³ Adjusted stop collar to lengthen stroke.⁴ Average.⁵ Hopper practically empty; hopper full, 3.5 pounds at start.

The feeder illustrated in figure 9 is of somewhat similar construction to that illustrated in figure 8, except that the dust is pushed from a narrow trough by a blade attached to a reciprocating rod. An agitator consisting of a loop made of spring-steel wire attached to the blade and extending into the hopper prevented the dust from clogging in the opening between the offset-hopper compartment and the trough. Results of tests made with this feeder are shown in table 3.

A cylindrical hopper with a dispensing mechanism designed to offset the effect of head on the rate of feed is illustrated in figure 10. The upper portion of this feeder is cylindrical with the lower portion in the form of a frustum of a cone. A rotating shaft, to which are attached an agitator and a circular plate, is mounted in the hopper. The plate is attached to the shaft just below the opening in the bottom of the hopper, and the agitator arms, made of spring-steel wire, extend upward along the sloping sides. Additional agitators made of short pieces of spring-steel wire attached to the plate extend upward into the lower part of the hopper. An adjustable scraper mounted just above the circular plate scrapes the dust from the plate as the shaft and plate rotate. This feeder is of the type used on some fertilizer distributors.

The rate at which this feeder will dispense dust was found to depend largely on the position of the scraper with reference to the center of the plate, the speed of the plate, and the spacing of the plate below the opening in the bottom of the hopper. It was necessary, however, to operate the plate at less than 100 revolutions per minute, as with greater speed centrifugal force caused the dust to slide off the plate. Table 4 gives results of tests with this feeder using different settings of the plate and scraper. The cylindrical hopper with revolving plate gave fairly good results, except that the feed was usually somewhat heavy immediately after starting the machine with a full hopper. From this point until the hopper was emptied, except for that remaining in the conical section, the rate of feed was usually quite uniform. As the conical section emptied, the rate of feed usually decreased.

In an effort to overcome these irregularities in rate of feed, another form of feeder for use in the cylindrical hopper was constructed as is illustrated in figure 11. A plate with a hole for the shaft, and two small holes through which the dust was to feed, was attached to the bottom of the conical section. The agitator with spring-steel arms, shown in figure 10 was retained and a piece of spring-steel wire attached to the shaft just above the plate as an agitator to prevent the dust from bridging over the small holes in the plate. A cup with two large holes in its bottom, which were out of line with those in the plate, was attached to the hopper just below the plate. A collar with four radial blades rigidly attached to the shaft between the plate and the bottom of the cup acted as a wiper for raking the dust from beneath the small holes in the plate and through those in the bottom of the cup. The speed of the wiper was 24 to 27 revolutions per minute. Tests were made with plates having $\frac{3}{16}$ -, $\frac{1}{4}$ -, and $\frac{3}{8}$ -inch openings. The results are given in table 5.

TABLE 5.—*Size of plate openings¹ as affecting discharge rate of organic mercury dust from cylindrical-hopper feeder illustrated in fig. 11*

Flow per minute with opening of size indicated					
$\frac{3}{16}$ inch		$\frac{1}{4}$ inch		$\frac{3}{8}$ inch ²	
Test no. 1	Test no. 2	Test no. 1	Test no. 2	Test no. 1	Test no. 2
<i>Ounces</i>	<i>Ounces</i>	<i>Ounces</i>	<i>Ounces</i>	<i>Ounces</i>	<i>Ounces</i>
0.76	0.76	1.21	1.20	5.49	4.86
.85	.76	1.16	1.19	5.49	4.93
.76	.76	1.12	1.16	5.63	4.74
.79	.76	1.13	1.14	6.29	4.67
.79	.76	1.14	1.12	5.92	4.78
.79	.76	1.15	1.12	³ 3.54	4.78
.79	.76	1.18	1.12		5.09
.78	.76	1.16	1.14		³ 2.01
.78	.76	1.16	1.13		
	.76	1.16	1.18		
	.76	1.18	1.23		
	.71		1.26		
	.71		1.12		
	.75		1.06		
			³ 4.42		
4.79	4.75	⁴ 1.16	⁴ 1.15	⁴ 5.76	⁴ 4.83

¹ 2 openings in plate diametrically opposite.

² Dust in hopper at start, 7 pounds.

³ Not used in computing average.

⁴ Average.

That feeders of the type illustrated in figure 11 are not new is indicated by patents of similar devices.

The power required for operating feeders of the type illustrated in figures 8 to 11, inclusive, is small. A $\frac{1}{20}$ -horsepower electric motor was used in testing the cylindrical-hopper feeders. A larger motor was used on the feeder illustrated in figure 9 than for the cylindrical feeders, because of the convenience of a line shaft and speed-reducing equipment driven by this motor. However, the indications are that the $\frac{1}{20}$ -horsepower motor would have been sufficient. The movement of grain through an automatic grain-weighing device furnished ample power for the feeder illustrated in figure 8.

GRAIN AND FUNGICIDE FEEDER

Along with the development of fungicide feeders, it was necessary to adapt a feeder to some device for accurately feeding the grain to a mixer. As previously stated, difficulties were experienced with some commercial treaters in synchronizing the feeding of the dust and grain. In developing such a feeder, a device was constructed with valves for automatically filling and emptying compartments in the body of a feeder.

This feeder, illustrated in figure 12, has two compartments and the grain is fed to it from a hopper on the top of the machine. A deflector plate or upper valve attached to a shaft extending through the body of the feeder just above the partition, shunts the grain into one or the other of the compartments. Valves forming the bottom of the compartments are attached to a shaft extending through the feeder just below the partition. Weight arms, rigidly attached to and extending radially from the lower shaft forming an angle of about 135° , carry adjustable weights. The upper and lower valve shafts are tied together by levers or connecting bars. As one compartment fills with grain, its bottom valve is pushed down, thereby closing the bottom valve on the second compartment and shifting the top valve to deflect grain into the second compartment while the first empties. The connecting bars on the upper and lower valve shafts are slotted at the top ends, so that the movement of the lower valve is almost completed before the top valve is moved. This construction provides quick shifting of the top valve and also positive action as the weights are moving rapidly by the time the end of the slot engages a pin in the lever and trips the upper valve. Such construction also prevents incoming grain from interfering with or retarding the closing of the lower valve, since the lower valve will be nearly closed before the upper valve or deflector shifts.

A fungicide feeder of the offset-hopper type, illustrated in figure 8, was attached to the side of the grain feeder and the reciprocating slide or dust ejector connected in such a manner as to be operated by the movement of the valves. Holes were cut in the sides of the grain feeder and chutes provided for dumping the dust ejected from the fungicide feeder into the compartments. As the lower valve is pushed down by the weight of the grain on one side the opposite valve is closed, automatically shifting the top valve. As the top valve shifts a U-link transforms the oscillating motion of the upper valve shaft into reciprocating motion of the dust ejector. Thus each time the valves shift a charge of dust is deposited in the compartment as it begins to fill with grain.

The length of stroke may be varied by moving the stop collars or by having the U-link adjustably positioned below the upper-valve shaft. The end of the U-link moving toward the feeder does not immediately engage the stop collar. This initial free travel of the U-link on the rod extending from the slide permits the weight arms and valves of the grain-feeding device to nearly complete their movements before operating the fungicide feeder. Thus the operation of the feeder does not take place until the resultant leverage action of the grain-feeder weight arms is reaching its maximum. The operation of the fungicide feeder serves as a cushion in preventing the weight arm from causing too great a jar as it contacts the stop.

The grain-weighing device was originally designed for tripping with a bushel of grain. It was found to work much better, however, with the weights set to trip on a lesser amount. In adjusting the machine for wheat, barley, and oats it was found to work satisfactorily when set to trip on approximately one-third of a bushel of each kind of grain.

Considerable trouble was experienced with grain wedging between the edges of the lower valves and the walls of the feeder and clogging the machine. In overcoming this difficulty the edges of the lower valves were cut back approximately one-half inch and ledges inserted for the valves to rest against when in the closed position.

For the successful operation of the machine it is also essential that the grain fall freely from a hopper above the upper valve. This valve will cut across a falling stream of loose grain, but will clog if the grain is confined in a slowly moving column.

In testing the machine for accuracy of feed in the laboratory small lots (2 to 6 bushels) of wheat, oats, and barley were used. Due to variations in the physical characteristics of such grain, adjustments of the weights on the weight arms were necessary in changing from one kind of grain to another and also for different rates of feed for a particular kind of grain. After the machine had been calibrated it was set up in a commercial seed house with a mixing spout of the type illustrated in figure 6 and tested while treating approximately 100 bushels of wheat, results of which are given in table 6.

TABLE 6.—Results of tests of the grain and fungicide feeder illustrated in fig. 12 when treating wheat with organic mercury dust in a commercial seed house.

Text no.	Time required	Wheat treated		Trips	Wheat per trip	Dust used		
		Total	Per hour			Total	Per bushel	
	Minutes	Bushels	Bushels	Number	Bushels	Grams	Grams	Ounces
1	4.1	20	295	64	0.3125	318	15.9	0.56
2	16.5	80	291	242	.330	1,176	14.7	.52

During the 1935 season this machine was used for treating approximately 25,000 bushels of wheat. Two additional machines of this type constructed by the owners of the seed house were used for treating a considerable quantity of barley and oats during the 1935 season. These machines were similar in principle to the experimental unit but differed from it in certain details of design. Only one weight arm was used and attached to the lower valve shaft in such manner as to be in a vertical position when each of the lower valves was in the half-open position. Dust-tight connections also were provided between the fungicide feeder and the body of the grain-weighing device. Another improvement was the elimination of sloping sides in the bottom of the compartments just above the lower valves. With this arrangement the compartments emptied more quickly than in the experimental machine.

GENERAL PRECAUTIONS IN HANDLING FUNGICIDES

In working with dust fungicides every reasonable effort should be made to avoid inhaling them or bringing them in contact with the skin. Copper dusts are known to cause severe nausea when inhaled. Some workers who are especially sensitive to copper dusts may be incapacitated thus for several days. Formaldehyde dusts give off fumes of formaldehyde which are extremely irritating to the nasal passages and to the eyes. Persons peculiarly susceptible to so-called mercury poisoning should take special precautions when working with mercury dusts, especially those containing organic mercury compounds.

When inhaled by susceptible persons organic mercury dust may cause severe headaches, bronchial trouble, and even digestive derangement. It also should be remembered that the action of mercury is cumulative, so that although no symptoms may be evident at first, severe injury may follow continual inhalation of mercury dusts.

Organic mercury dust was found to have a powerful vesicant action. In working with fungicide feeders the senior author on several occasions found it necessary to plunge his hands into the dust to make adjustments to the mechanism. Later large blisters appeared on the palms of his hands and between his fingers, similar to those caused by contact of the skin with hot metal. Blisters also developed as a result of handling dust-covered parts of the feeders while making adjustments. With the formation of new skin the hands peeled. Blistering was especially severe when the dust got into gloves or up sleeves and was thus held in contact with a skin moist with perspiration, because moisture greatly activates ethyl mercury compounds.

When seed dusting is done in a small way it should be performed outdoors or in a room with effective cross ventilation. When done on a commercial scale the dust-laden air should be effectively disposed of by properly located suction fans. An efficient respirator or dust mask should be worn over the nose and mouth, and when used with organic mercury dusts the air strainers should be kept dry. Persons perspiring should avoid having their moist skin come into contact with such materials.

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